

REFORMING EDUCATION

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BACKGROUND

Education has changed very little over the last 200 years or so, particularly in the Higher and Further Education sectors. Indeed it is one of the few areas of public service that has not been the subject of significant reform. Of course, there have been many attempts at structural reforms, curriculum development, technological advances etc., but strangely, the core area of how education is actually delivered, or, more accurately, how people learn has remained off limits in most of the developed world.

In considering the overall efficiency of the education process, passing knowledge from the teacher to the student, many educators believe that the traditional methods are very inefficient with some estimating efficiencies of less than 20% when compared to more flexible student centred methods. In the current climate of fiscal austerity, operating in most European countries and in particular budget reduction of public services, a transformation that can significantly increase the efficiency and effectiveness of the education process should be very welcome.

The traditional education model is essentially teacher centred where the teacher is considered to be responsible for the entire educational process and students are expected to learn in the same way, at the same time, and usually in the same place. Indeed this model was developed because of a scarcity of resources: educated people, books, libraries, public buildings etc., when the rapid expansion of advanced education was required to power the industrial revolution. Prior to that only a privileged few had access to advanced education and this was usually acquired by studying 'at the feet' of a master who essentially used Socratic problem solving methods.

Teacher centred methods have been very successful in coping with the incredible expansion of education, where most countries now have more than 50% of their population exposed to advanced education. Meanwhile, technological developments in communications and multi-media have progressed to the extent that the restrictions that underpin the traditional methods are no longer applicable.

So we are at a cross roads; it has been incredibly difficult to engage educators in any reform process so that we can determine how best to revise education methods to make the best use of the knowledge, skills and commitment of teachers with the capabilities and availability of advanced communications systems , software platforms and multi-media systems.

This white paper, sponsored by the European Region Information Society Association (eris@), discusses the opportunities that student centred education methods present to the European Regions. It describes some of the methods that can be used to undertake such a reform and describes a particularly successful transformation undertaken in the senior high schools of Scotland.

LIBERATING TEACHERS

The main response to this opportunity has been to use technology to enhance the traditional teacher centred approaches. Interestingly, one of the fastest technologies to be adopted in the class room was the 'interactive white board' that allowed teachers to access and utilise other resources during their class but still remain in control of the delivery. Similarly 'virtual learning environments' have been adopted in most institutions but are usually used as a sort of electronic wardrobe or storage cupboard for learning resources, whilst the underlying pedagogy remains unaltered. Indeed, many studies have shown that the introduction of technology in an augmenting way has hindered or slowed the process of pedagogical change, with teachers believing that they are 'modern' if they use new technology. However, the overall effect of this use of technology is to reduce or obscure the actual amount of human contact in the educational process often to the detriment of learning efficiency.

The real obstacle to education reform is people. For too long teachers have regarded their position of being in the exclusive source of education as being fundamental to their status and to the delivery of effective education. Yet, through the internet students now have direct access to almost limitless sources of knowledge and can consult this directly, often as and when needed. So already the prime position of the teacher, at least in traditional methods, is under threat.

Conversely, the introduction of technology, presents a significant opportunity to teachers to extend their role to design and manage the educational process rather than being solely responsible for its day to day delivery.

To do this, we need to understand what tasks are contained within the educational process and which are better done by teachers and which by technology; we need to match the requirements of the task with the capabilities of people and technology. Essentially we need to use our most expensive resource for those tasks which demand human expertise and cannot, maybe ever, be undertaken by a regular or automated system.

In the traditional approach most of the effort goes into the preparation and delivery of content, i.e. knowledge that has to be learned and understood. Actually, this normally represents a considerable waste of effort as sources of content, from books to digital animations, are ready available for most subjects and levels. This is usually justified as tailoring the knowledge to the situation or bringing a unique perspective to the subject, and there is no doubt that sometimes this is the case. However, in the majority of cases, it results in poor imitations of what is already readily available.

This is particularly true for digital multi-media content, where trained teachers are often diverted from their teaching task to create animations or slide presentations for their particular class. The design and construction of these is a specialised area and one that is more efficiently undertaken by learning designers and software developers

We need to liberate teachers from the tasks associated with content delivery and presentation so that they can use their human skills to motivate, interact, support, empathise and guide students to enjoyable and successful learning experiences.

DON'T LECTURE ME

The traditional didactic view of education is that I tell you, you listen, I ask you questions to check that you understand, or at least remember, and then we move on to the next part. However, that's not how most people learn. Some people like to try to acquire the knowledge themselves, often by experimenting or testing ideas, and then seek help only when they cannot sort it out for themselves.

Confucius say: "I would never attempt to teach someone until they have failed to learn it for themselves"

So people learn in different ways and it can also vary by situation, time, subject, motivation etc. If we want to reform education we should derive an approach, or methodology, that accounts for these different learning styles.

Such an approach would be student centred where each student can use the available resources, human and automated, to facilitate their preferred style of learning. There are many approaches to this but a simple way is to break the learning process into the following tasks:

Motivation: to inspire and convince the learner of the importance of the subject

Acquisition: to absorb the knowledge from its source

Contextualise: to apply the knowledge to a relevant situation

Evaluate: to assess if the knowledge is properly understood

Using this simple classification we can start to understand which tasks teachers and computers are more suited to. For example, it is clear that people are better at motivating others than computers will ever manage; similarly, people are better at contextualising and explaining what something means within the experience of a particular learner than computers can manage; however, computers are better at presenting and demonstrating knowledge in a clear and explicit format, they are also more consistent, reliable and inexpensive; similarly evaluation can often be automated although for qualitative assessments automated means are still under development.

We can also use this classification to describe the different learning styles that a particular student may adopt. However, more importantly, if the classification is used to develop the learning process such that the various tasks are clearly separated then the student may combine the tasks in whatever way they feel best for a given situation. Technically, this results in a declarative system i.e. represented independently of use, rather than a procedural system which has its use built in to the representational format.

In our view, this is the key to effectiveness of education reform. To develop the learning resources independently so that they can be used to support the students preferred learning styles and personal constraints i.e. student centred. A corollary is that we can choose the most effective way to execute or deliver each stage to maximise the efficiency of the overall education process. Such insights are not merely pedagogic and theoretical but can result in a much more effective education system that significantly improves standards, reduces costs and increases efficiency.

STUDENT CENTRED LEARNING

The benefit of the above classification and approach is that various forms of pedagogy can be implemented by different implementations of each task and ordering or usage of the resources. For example, Student Centred Learning, can be realised based on the following realisation and ordering of tasks.

Motivation

This is best done directly by the teacher as human interaction is by far the most effective motivation for most students. It need only take 15/20 minutes however to explain the importance and relevance of a particular topic and to place this into context of the overall course/module being studied. The teacher can also point out difficult areas and recommend particular approaches to overcome these. These sessions should not attempt to teach or transmit knowledge about the subject being studied

Acquisition

This is where the student acquires knowledge and understanding of the topic. Using the capabilities of current multi-media systems a combination of textual descriptions, animations and activities can be developed that present the knowledge in a clear way, promote greater understanding through the visualisation of interactive animations and confirm understanding through embedded quizzes. Such interactive e-learning materials can be expensive to produce but have the benefit of allowing the student to study at a time and pace that is convenient for them and therefore more effective

Contextualisation

This is when the subject being studied is put into context within the student's prior knowledge and the local environment. It is best done through specific examples related to the experience of the teacher. It should be very interactive with the teacher with the aim of consolidating the learning and remediating any misconceptions or difficulties. This task can be challenging but rewarding for the teacher as students will already understand much of the subject and be able to articulate sometimes difficult but reasonable questions to the teacher.

Evaluation

At the end of each topic or section a simple assessment of understanding should be conducted before progressing to the next topic. This can be in the form of automated assessment, if the subject will allow, or written assessments or essay work. Following these tasks puts the student at the centre of the learning and able to determine progress and hence building confidence as the study of the subject progresses. It is also more efficient with the utilisation of staff time.

The increase in effectiveness of these methods results in a shift of resources required for the educational process. Using traditional methods the balance of effort between the teacher for a typical topic of 10 student learning hours would be approximately 5 hrs teaching and tutorial work by the teacher, and 5 hours self study by the student. With student centred learning this balance shifts to something like 3 hours teacher involvement and 7 hrs student learning, depending, of course, on class size, subject level, student ability etc. However, conservatively, this offers a 25% efficiency increase in the most expensive resource in the educational process. This is worth achieving especially as it also increases education outcomes

PROMOTING REFORM

Education reform is hard. The very nature and importance of education places teachers in the crucial role where their freedom is fundamental to successful outcomes. Unfortunately too many see the gradual introduction of technology as a threat rather than as an opportunity.

The key to overcoming these fears is to establish a framework and support to allow change to happen willingly and organically. Such a framework for promoting education reform requires that a number of services and facilities need to be put in place to support the change. Such services include:

Project Planning

Education reform projects need careful planning and significant financial investment. The educational justification and objectives must be explicit and measurable.

The project needs to be underpinned by a financial model that clearly shows the investment required and the eventual return on investment within an identified timescale

A Project Board should be established consisting of the key stakeholders, including representation from the teachers involved in the reform. This Board should have overall responsibility for the project and ensuring that the necessary budgets and resources are in place

A Project Management Team consisting of the Project Manager and those responsible for the various services.

Content Development

This is usually the main activity within the project and needs to be specified, designed and managed very carefully.

It is assumed that a detailed curriculum for the subject to be taught is available, but surprisingly this is often not available or incomplete. The curriculum is then divided into a series of learning outcomes, normally called topics corresponding to one ECTS credit (30 hrs of student learning). This is an important activity as it underpins eventual reusability and composability of different curricula based on the same and extended topic 'library'. It is also important to create design guidelines so that the overall content has a similar look and feel.

We suggest that content development teams are established consisting of a teacher previously involved in the teaching of the subject and who is sympathetic to the education reform, a learning designer and a learning developer. The team specifies the design of the topic conforming to the design guidelines and normally the teacher authors the textual description and specifies any animations and activities involved in the topic. The team iterates the design until a complete topic is finished. The topic is then reviewed by the management team and accepted or revisions suggested.

Establishing the design guidelines and ensuring the review process is crucial to the professionalism of the process and the overall conformity of the content. Our experience is that initially it can be difficult to persuade developers to work to the guidelines but they quickly see the benefits of

working within a specific template. It also allows better estimation of development times and therefore overall time scale of the project.

Staff Development

Once a significant amount of content has been developed and reviewed, a group of staff not involved in the development of the content should be given some simple staff training about the ideas behind the project and the potential benefits. These staff should be asked to use the materials with a group of students and to feedback experiences, any errors in the materials and review the content for usability or accuracy.

This is really about buy in, as the training is relatively simple. It adds a lot of credibility if staff not involved in the project give it their positive endorsement

Pilot Programme

Once the full content for a complete assessable part of the curriculum has been tested, a pilot programme should be organised. The pilot programme should consist of 'live' usage of the learning materials within their target setting, but with either a restricted scope, e.g. a particular location, or a significant part of the curriculum. It should be the complete process so that the learning outcomes can be evaluated and compared to previous outcomes under similar situations.

Staff involved in the pilot programme should be inducted into the goals of the project and also into the ideas behind the project but not forced to accept a particular pedagogy. Indeed they may use the developed content as supplementary to their existing preferred resources.

However, it is our experience, that some staff will adopt the student centred approach with enthusiasm whilst others will take a more cautious approach perhaps using the materials to supplement their lectures or as the basis for homework or revision.

Community Building

This is essential. Staff not directly involved in the pilot nor in the development should have access to Newsletters and on-line bulletin boards, describing the developments, discussing the issues and responding to queries. In larger projects, an annual 'conference' can be arranged where teachers participating in the pilot, or full programme, can present their experiences with others.

This community is essential for evolving the use of the content from initial supplementary use to full student centred learning. However, it is our experience that this takes time, often two or three complete cycles of the curriculum is necessary to see this evolution.

It can also be useful if a member of the project team, preferably an author, commits to establishing a blog on the experience of being directly involved with both the successes and the frustrations shared with a wider audience.

Evaluation

It is crucial to evaluate the outcomes with respect to the original goals of the project and to compare the outcomes with the prior delivery of the same programme. If possible, it is preferable if an independent organisation can be engaged to undertake the evaluation. This gives much more credibility to the results even if they have to be presented in a balanced way to be seen to be objective.

The outcome of the evaluation should be used in subsequent revisions of the content. It should also be made available to the community and discussed at any open forum organised.

The evaluation should also include a financial report on the costs of the project, the change of operational costs associated with the delivery of the programme and an assessment of the return on the original investment.

Payback

Setting up the framework for change costs money. However, changing to student centred education results in much more effective use of staff time and resources, as well as increased education outcomes. This increase in efficiency can either be used to reduce costs or to do more.

The most directly measurable outcome is in education outcomes. Our evaluations have shown that students attain a grade, typically 10%-15%, higher than with traditional techniques. However, perhaps the biggest gain is a substantial reduction in the failure rate, up to 50%, and in particular many borderline students move to good passes. It seems that whilst all students get a lift from student centred students, it is the borderline students who seem to benefit more. Our view is that being able to study at your own pace and time that gives this benefit.

In financial terms, efficiencies of 25% are readily achievable. But this depends on the subject and students, and of course the teachers. It also allows more flexible use of resources allowing part time work. Also, the tutorial part, contextualising, can be done by practicing professionals, again giving more focus and relevance to the contextual sessions.

Our experience is that savings through reduced failures and drop out alone can be greater than the costs of the on-going support and maintenance.

The return on investment period is typically 5 years.

Sustainability

Care should be taken to ensure that the change is sustainable. Too many e-learning projects exist for the duration of the project funding and dissipate thereafter. Sustainability needs to be built into the initial project plan.

This requires a continuous maintenance team for the learning materials. This is often combined with further developments in other subjects. However, these materials need to be considered as an asset of the organisation and looked after and maintained like any other service required for the successful operation of the organisation. If they are not maintained they quickly become obsolete and the reform can stall before it reaches sustainability.

Our experience is that it takes two or three cycles of the delivery of the curriculum to generate momentum, up to five cycles to see real sustainable change, and up to ten cycles for the majority of teachers to have opted in to student centred learning.

It should not be forced; if it is right then staff will incrementally opt in. The trick is getting the momentum going and in this respect generating and sustaining the community is crucial.

However, it can be done.

THE SCHOLAR PROGRAMME

Background

The SCHOLAR programme is an initiative of Heriot Watt University, Edinburgh, Scotland. It was initiated and directed by the author in 1998 whilst he was Deputy Vice Chancellor at the University. The objective of the programme was to transform the teaching of Science and Mathematics in the Senior High Schools of Scotland. Prior to 1998, the number of students studying Science and Mathematics was in constant decline and this was impacting significantly in recruitment to Science and Engineering degree programmes across Scotland. The University agreed to invest significantly in the development of interactive e-learning materials for a wide range of science and engineering subjects and to develop the methodology above to promote student centred learning and to establish a community across Scotland to promote such developments.

The goals were:

1. Increase standards in science and engineering in the Senior High Schools across Scotland
2. Increase the number of students applying for entry to Scottish universities for Science and Engineering related degrees
3. Create a sustainable community to promote the education reform

The project was, and is, very successful. More than 100,000 students are now studying within the Scholar programme. Students have on average attained a grade higher than previously, the failure rate has halved and applications to related university courses have gone up by 30%. The programme is now sustained by a country wide SCHOLAR community of Education Authorities, teachers and researchers. The current cost of participation per student is less than the cost of a text book. More details and access to some of the materials is available at www.scholar.hw.ac.uk.

Project Planning

The project was directed by a Project Board, chaired by the author that met monthly and was responsible for budget control, project planning and overall direction. A Project Management Team was established consisting of senior representatives of each of the subjects being developed, the Head of the university's Learning Technology Centre and the Project Manager. This group had day-to-day responsibility for the execution and delivery of the project deliverables.

The project was arranged in three phases. The Pilot Phase, working with 5 Education Authorities located in the region around the University, the Roll Out Phase, where 80% of the Education Authorities in Scotland were involved; and the Sustained Phase, where nearly all Education Authorities are directly involved and make substantial contributions to extending the scope and the sustainability of the reform.

Content Development

This was the heart of the development. The University was fortunately to be able to exploit the experience and skills of the staff of its Learning Technology Centre (LTC) to guide the development of a very substantial content development programme.

Subject development teams were established consisting of a seconded teacher from a participating school, a learning technologist, and a member of the relevant department within the University.

These teams were responsible for authoring the materials and specifying and developing animations and activities within the materials. All materials were subject to an internal review process by other academic staff from the relevant department. The materials were developed to guidelines and style guides provided by LTC.

Initially, the subjects covered were Mathematics, Physics, Chemistry and Biology. Content for the complete Scottish Higher qualification and Advanced Highers were developed. This consists of two full years study in the senior High School. The materials were developed a topic at a time, corresponding to 10 hrs of learning in Scotland. At its peak the development process was producing one topic per week per subject.

The Scottish Government, through Scottish Enterprise, partially funded the direct costs of the materials development programme, with the remaining costs being borne by Heriot Watt University. As such the University retained the IPR and exploitation rights of the materials.

Following the success of the Pilot Phase, the subject scope was extended on other subjects and options within the Scottish Highers system. The programme now supports around 20 subjects.

Staff Development

This was a crucial activity within the programme. All teachers seconded or involved in the subject development teams underwent two days training in the authoring guidelines and style guides. It is important to emphasise that the authors were writing materials for use by others and had to be compatible with other topics and subjects.

As part of the Pilot and Roll Out Programmes, teachers within schools in participating authorities were offered one days training in how to access the Scholar materials and a wee bit on pedagogy, but this was not emphasised. We preferred that the teachers adopted the materials in a way that supported what they wanted to do rather than stipulate how to use them. This training was undertaken by some of the authors seconded to the subject development teams. It came as a welcome break from authoring but also exposed them to developments in other subjects.

The staff development programme was on-going throughout the project as successive Education Authorities decided to join in. During the roll out phase more than 600 teachers were inducted into the programme.

Pilot Programme

The pilot programme was restricted to the core SCHOLAR subjects, Mathematics, Physics, Chemistry and Biology at the Scottish Higher level. The participants were most of the Education Authorities in the region of the University. Significant effort was applied to ensure that the teachers involved in the pilot had a direct and immediate way to feedback any errors or corrections contained within the materials.

The pilot programme was funded by contributions from participating authorities to cover the operational costs of the programme. Great care was taken to separate the operational costs from the development costs to ensure that the IPR position was clear. During the role out phase the participating authorities used the materials under a license agreement between the authorities and the University

An independent evaluation of the pilot programme was undertaken by an external company of education consultants. This was an extensive evaluation conducting interviews with all stakeholders: government, education authorities, teachers, head teachers, students and developers. It considered both the qualitative and quantitative aspects of the programme.

The results were very supportive. All stakeholders were supportive of the project, some even enthusiastic. Given that this was an education reform this was quite an achievement. It was too early, of course, to see any real results from student centred learning but already improvements in grades were being detected and explicitly failure rates significantly reduced. The evaluation also gave the management team some very constructive advice about the extension of the project to the Roll-Out stage

Community Building

This is the secret. From the beginning the project was set out to 'belong' to the community, in this case science teachers in schools. Every possible opportunity was used to inform and involve teachers in decision making and dissemination of experience.

If a teacher showed any interest in the developments, particularly if they were critical, they were quickly seconded to the programme, either to the subject development teams or staff training or even just to events and evaluators.

The most successful part became the annual SCHOLAR conference. About 500 teachers attend this event annually. This was organised as a short update on the project and people, but with most of the information and activities coming from the teachers who were actively using the materials. In the afternoon, open workshops were held with particular teachers showing their innovations or discussing particular issues. The outcomes of the workshops were recorded and fed back to the conference delegates at the close of the conference. The outcomes were also discussed by the project Management Team for impact and inclusion within the project.

Some use was made of on-line groups, but this was still early days for specialised network groups or even social networking. More use of these would be made today.

Evaluation

Apart from the on-going internal reviews and monitoring and assessment of results, the project was subject to two extensive external reviews at the end of the pilot phase, after two years of operation, and once the roll out phase had been established. These reviews were funded by the Education Department of the Scottish Government and were conducted by separate independent education consultancy organisations. These reports are publicly available or from the author.

The evaluation of the Pilot Programme showed that the materials were being adopted, that in general they were considered to be good quality, although some refinements and corrections were necessary. It considered that about 20% (100 teachers) of the potential teachers were using the materials. Those that did were very supportive. The remaining teachers were split between 'interested but not yet involved' and sceptical (of technology in education).

Students were early adopters. Even when their teacher was not involved they had access to the materials and were using them in their own way. Feedback from students was very positive, especially the animations and on-line quizzes which really supported their learning.

In terms of quantifiable outcomes the report concluded that there were indications that standards were increasing but it was too early to quantify these. The report strongly recommended that the project continue to the Roll Out stage.

The next evaluation was undertaken after four years of operation. By this time most Education Authorities in Scotland had joined; about 500 teachers and 50,000 students were registered and participating. This evaluation was very positive:

- The average grade in most of the subjects had increased by at least a grade (~15%)
- The failure rate a number of drop outs halved from previous years
- Many students who had been predicted to achieve borderline grades, from previous exams, actually achieved two or more grades higher than expected
- Significant testimonials from students were quoted from students saying that they would not have gained entry to their chosen university, often the top universities in the UK, without access to the SCHOLAR programme.
- Most teachers (60%) within participating schools were using the materials in some way or another
- Most teachers recommended the continuation and expansion of the programme
- Some teachers said they could not do without the SCHOLAR materials
- A minority (~20%) were using the materials in a student centred style

These results encouraged the team to continue the programme, and to expand the scope, into non-science subjects e.g. Foreign Languages and Management Subjects and to transfer the programme onto a self funding sustainable basis

Payback

The programme development costs were funded by Heriot Watt University, with partial support from Scottish Enterprise. The operational costs were funded by a subscription model with the participating Education Authorities.

Development Costs

The full development costs were large, several £millions. This included all direct and overhead costs of staff contributing to the project. As the University funded the developments it retained the IPR and Exploitation Rights. Clearly the return on investment of this order takes some time. The University had a number of channels for recouping the costs.

As noted earlier the major motivation for the project was the steady decline in students applying to study Science and Engineering subjects. Following the introduction of SCHOLAR the applications to the University increased significantly, estimated at 25%. This was probably due to the enhanced visibility of the university through the SCHOLAR programme, the materials were branded with the university's logo. Also increasing standards made more students eligible to apply. The financial return on this has not been quantified but an increase of 100 students increases funding to the university by £1m, and this occurs every year. This is substantial.

As the university retained the IPR the materials can be exploited internationally. Agreements to use the materials have been set up with Education Authorities in England, Wales and Northern Ireland

and also in several overseas countries. These are commercial agreements and result in revenue to the University

As there is an overlap between the final year in School education and first year of the four year Scottish degree, the materials can be used within the university to support the delivery of these subjects. This represents a potentially significant saving to the University and the opportunity to increase standards. However, the take up within the University has been slow. An opportunity for a further education reform project perhaps! It also shows that the availability of e-learning materials alone is not enough to ensure their adoption or stimulate reform.

Operational Costs

The operational costs were funded by the Education Authorities directly. Each year an operational budget was established to cover the costs of staff development, the SCHOLAR conference, copies of the printed materials for each subject etc. The annual cost of the subscription for participating authorities was around £15,000. This increased only marginally as the number of authorities expanded.

The subscription cost was marketed as being equivalent to the cost of half a teacher. At that time in Scotland there was vacancies in most schools for science teachers so SCHOLAR provided an opportunity to meet that requirement. Also, all students received printed texts for the core science subjects, from printable versions of the on-line materials. This was a significant cost.

Overall the cost of participation per student to the Education Authorities was less than half the cost of a published text book.

Sustainability

The SCHOLAR programme has continued to grow. More than 100,000 students are now accessing the materials on a regular basis. All Education Authorities in Scotland are now members. Subject scope has been extended to include French Language, Management Studies, Computer Science and Information Technology. To the authors knowledge no further external evaluations have been undertaken.

The 'ownership' of the programme, but not the materials, has now moved to the consortium of Education Authorities. The management of the programme is now the responsibility of the consortium but the operation and organisation is devolved to an operational team within Heriot Watt University. This provides a sustainable model for the future of the programme and a mechanism for the Education Authorities to make further investment.

SUMMARY

Education Reform is hard, but can be done if organised carefully. The benefits of student centred learning to students, teachers and education organisations are substantial. However, it needs significant prior investment, but results in defined payback both in terms of educational achievement and efficiencies.



ERISA has adopted these ideas as the basis for the educational theme within its revised remit. As such it welcomes interest from member regions interested in exploring these reforms, either individually or in a multi-region collaboration.